Slurry Corrosion Behavior as It Relates to Improved Copper CMP/Low k CMP Process

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The announcement of the 1 GHz chip by IBM in 1997 relied on the change of chip-wiring material from Al(Cu) to Cu and significantly intensified investigation of that material for application to back end interconnections. Transistor switching speeds and density increase the RC time delay of interconnects play an increasingly significant role in limiting the maximum clock frequency of an integrated circuit. Copper with its low resistivity and electromigration resistance is a natural choice for the conducting material in next generation smaller, faster chips. In addition, to fully realize the potential performance gains IC's will have to integrate ultralow k materials (k<2.5). These low k materials are basically composites of a polymer and pores of air. By incorporating pores into the film the primary tradeoff is mechanical strength. One area of uncertainty is these materials ability to withstand the forces of CMP.

This paper presents a traditional look into the corrosion characteristics of copper CMP slurries but puts them into a new context. There are several approaches for 1st step copper polishing currently on the market. There are the alumina based slurries, low solids colloidal silica based slurries and no abrasive slurries. Approaches include as the oxidizer 1 % peroxide, 4 % peroxide, 9% peroxide and hydroxylamine. The measured pH's range from near neutral to almost 3. This is not to mention the various "invisible" functional components of film forming agents, complexing agents and surfactants included in each composition. These differences have a profound impact on the corrosion behavior and more importantly the nature of the passiviating film. One example that has been presented is the abrasive free process (AFP). The AFP approach requires only the interaction with a IC1000 urethane pad as the mechanical component. This is in stark contrast to an alumina based slurry where the abrasive is mechanically aggressive. The nature (physical properties) of the passivating films must be dramatically different in these two cases. Even though we have not measured a physical difference, the difference can be inferred by the factors influencing the kinetics of repassivation, namely, the peroxide concentration. The alumina slurries have 4% peroxide and the AFP has almost 9%. This concentration difference changes the relative reaction rates profoundly and probably contributes to the films that complement the respective mechanical contributions.

We will present, in another paper, friction measurements and their importance in the development of copper/low k CMP processes. This work will present complementary electrochemical data. In addition, this work will survey the corrosion behavior and correlating polishing data of several slurry compositions. Repassivation and corrosion kinetics will be shown that compliment the friction data and that give insight into what might be inherently different about the different passivating films. In addition, the advantage of the through the pad slurry delivery of an orbital tool to the important reaction kinetics will be presented. It has been found that some of these new chemistries are ultra depletion sensitive which causes instabilities in the polishing process. Efficient material transport inherent to the orbital carrier design overcomes these problems and delivers superior copper polishing results. In conclusion we will present a give chemistry and match it to the ideal mechanical component and chemical delivery for improved planarization and process conditions for the integration of copper/low k materials. This approach may be useful for the development of the next generation copper CMP process.